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Technical Note 2-68

AIRCRAFT INSTRUMENT PANEL PLACEMENT

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John A. Barnes

January 1968

HUMAN ENGINEERING LABORATORIES

ABERDEEN PROVING GROUND, MARYLAND

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ABSTRACT

The placement of the aircraft instrument panel has been governed by the 1947 recommendations of the Armed Forces-NRC Vision Committee. This distance, 28 inches from eye to panel, is not always compatible with present-day aircraft designs. A method for determining the placement of the instrument panel is developed and the maximum allowable eye-to-panel distance is given in this paper.

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AIRCRAFT INSTRUMENT PANEL PLACEMENT

INTRODUCTION

The placement of an aircraft instrument panel appears to be a simple matter. Military standards describe the field of vision required for the various types of aircraft, measures are available which anthropometrically describe the population that will use the aircraft, and much experimental data has been published concerning letter heights, stroke widths, viewing distances for various illumination levels, and optimal meter size. In the past, instrument panels have been placed so that the eye-to-panel distance was 28 inches. This was the distance recommended as a standard by the Armed Forces-NRC Vision Committee in 1947. The modern aircraft, especially light-weight rotary-wing types, cannot readily conform to this recommended distance.

This paper will present the various limiting factors concerning instrument panel placement and will recommend a method of determining the most economical envelope of instrument panel placements.

VISUAL FACTORS

A study by Obermayer and Muckler shows a mean preferred eye-to-panel or viewing distance of 29.19 inches with over half of the mean preferences falling in a three-inch range (27.63 to 30.55 inches). Figure 1 displays these results.

While preference is a minor design criterion, it is a factor for consideration. A more important factor in determining design is efficiency in use. Thus, for the aircraft instrument panel, the ease with which various indicators may be read is important. The conditions considered here were those specified by several publications; e.g., The Human Engineering Guide to Equipment Design, MIL-STD- 803A-1 (USAF), and Vision and Visual Perception. For low levels of illumination (.1 foot-candle), the minimal letter/figure height for critical markings was given as .15 inch with a stroke width of .019 inch (1/8 of the letter/figure height). These dimensions were verified for this paper by measuring the markings on actual aircraft instruments.

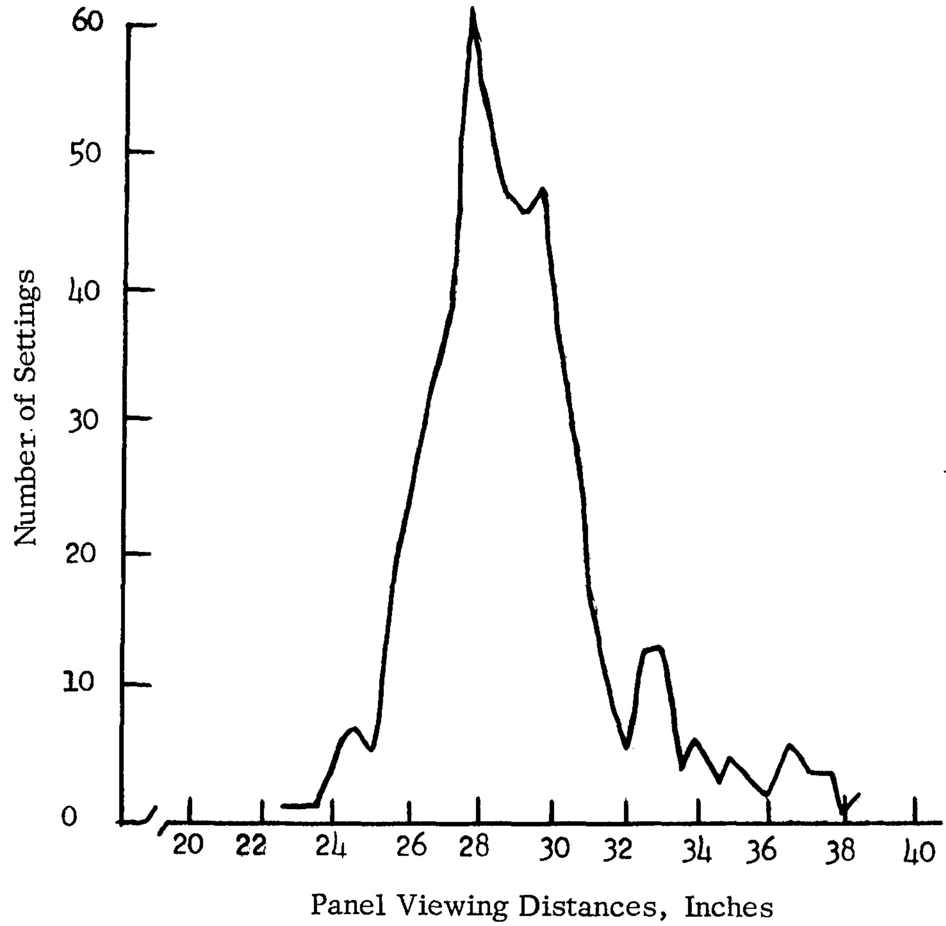

Fig. 1. DISTRIBUTION OF PANEL VIEWING DISTANCE SETTINGS: ALL SUBJECTS, ALL TRIALS. BASED ON 560 INDIVIDUAL SETTINGS

Given constant illumination and contrast, detectability and legibility are determined by the visual angle subtended by the letters or figures. Indicator figure detectability is required 100 percent of the time. Detection probability as a function of visual angle is given in Figure 2. This graph shows that a visual angle of 1.6 minutes or greater is required for 100 percent detectability. The visual angle is determined by the following formula: $\theta = 2 \text{ arc tan } X/2D$ where X is the letter height or stroke width and D is the eye-to-panel distance. Table 1 gives the visual angle and acuity values for a .15-inch letter height with a stroke width of .019 inch for an eye-to-panel range of 24 to 40 inches. The acuity value is computed as 1/Visual Angle expressed in minutes of arc.

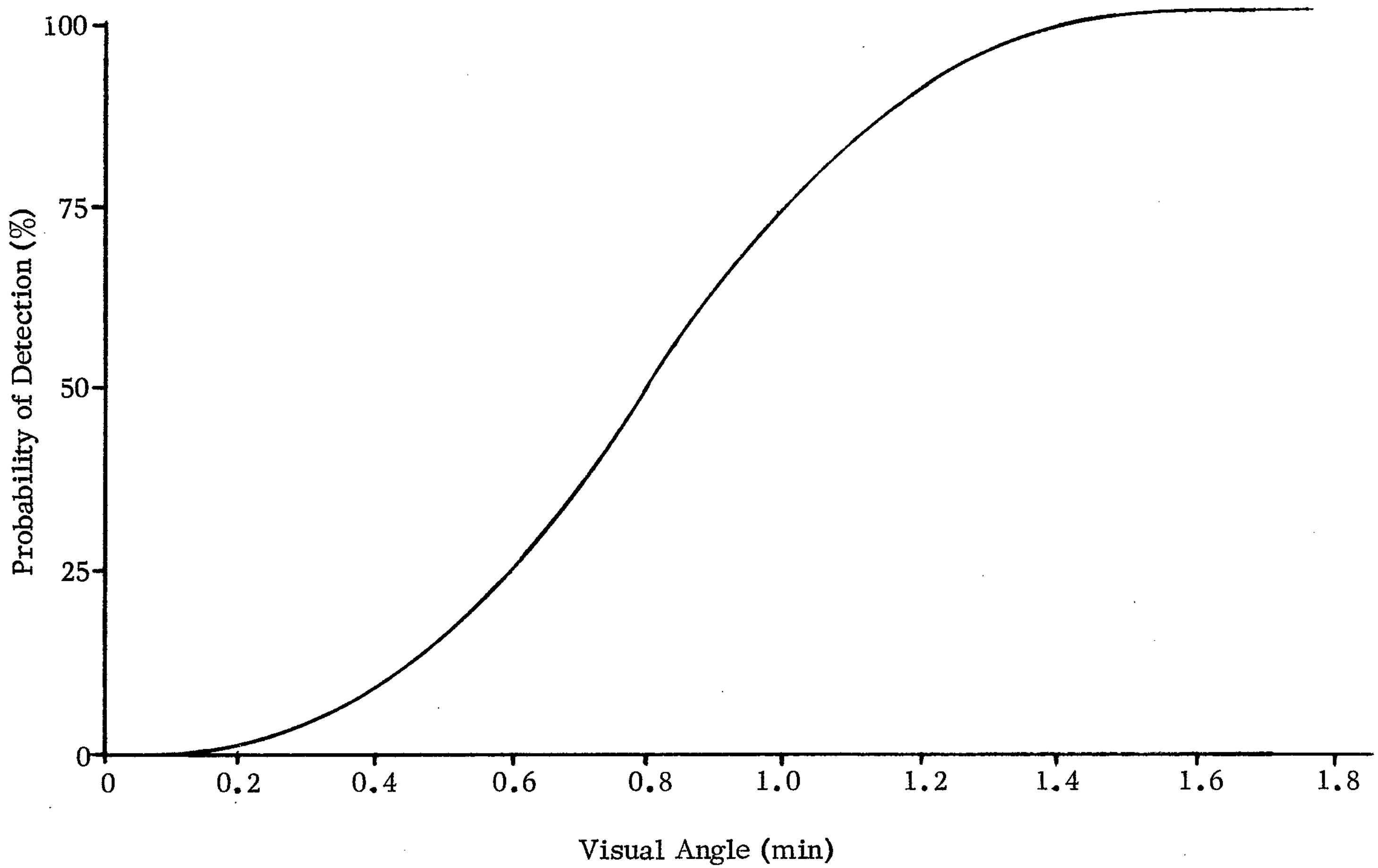

Fig. 2. PROBABILITY OF DETECTION AS A FUNCTION OF THE VISUAL ANGLE GIVEN CONSTANT ILLUMINATION AND TARGET SIZE

TABLE 1

Constant Letter Height and Stroke Width

Constants:	.15 inch Letter Height	.019 inch Stroke Width	
View Distance (Inches)	Visual Angle H (Minutes)	Visual Angle W (Minutes)	Acuity W
24	21.50	2.68	.3721
25	20.62	2.57	.3883
26	19.80	2.47	.4040
27	19.10	2.37	.4188
28	18.40	2.30	.4386
29	17.72	2.21	.4520
30	17.16	2.16	.4651
31	16.62	2.10	.4819
32	16.13	2.02	.4969
33	15.62	1.93	.5128
34	15.16	1.88	.5263
35	14.72	1.83	.5442
36	14.32	1.75	.5594
37	13.88	1.72	.5755
38	13.55	1.70	.5882
39	13.23	1.63	.6060
40	12.85	1.60	.6201

TABLE 2

Constant Visual Angle

	Constant Angle: 18' 24"	
Panel Distance (Inches)	Letter Height (Inches)	Stroke Width (Inches)
24	.129	.016
25	.134	.017
26	.140	.017
27	.145	.018
28	.150	.019
29	.156	.020
30	.161	.020
31	.167	.021
32	.172	.022
33	.177	.022
34	.183	.023
35	.188	.024
36	.194	.024
37	.199	.025
38	.204	.026
39	.210	.026
40	.215	.027

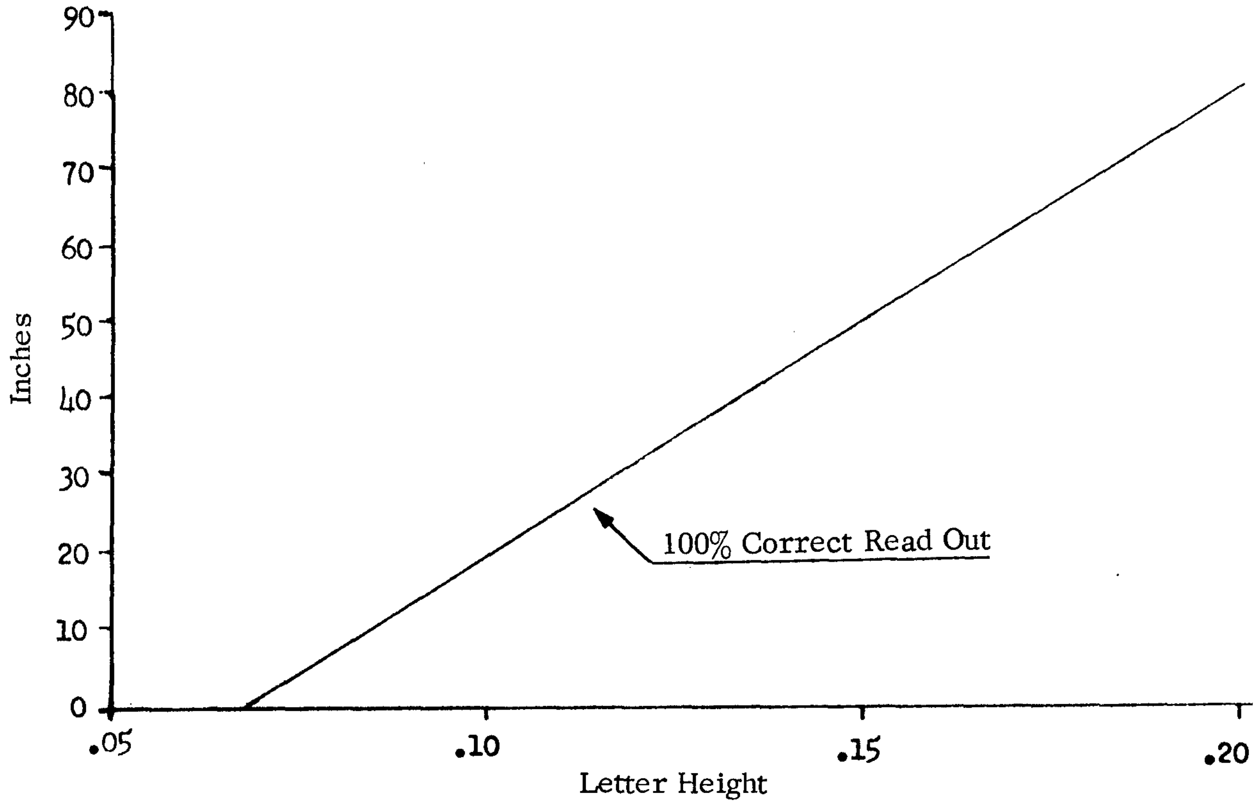

Fig. 3. VIEWING DISTANCE AS A FUNCTION OF LETTER HEIGHT GIVEN A CONSTANT 30 FL LUMINANCE LEVEL

In Table 2 the visual angle is held constant and the letter height and stroke width are varied to show the change necessary to maintain a constant visibility throughout the given distance range.

A study by Murrell et al using Royal Navy men with 20/20 vision and luminance levels of 30 foot-lamberts reported that a visual angle of two minutes of arc gave the optimal percentage of correct readings and speed of reading. Two minutes of arc is also recommended by Platonov. The relationship of letter height and reading distance as reported by Murrell et al is shown in Figure 3.

Luminance level or level of illumination is a critical factor in determining letter size. If the letter size is fixed and the requirement for 20/20 acuity is maintained, then the minimum level of illumination must be specified. Table 3 from Tscherning shows the relationship between illumination and visual acuity. It can be readily seen that an illumination value of .139 foot-candles is necessary for an acuity of 20/20.

ANTHROPOMETRIC FACTORS

One other factor in panel placement is the physical size of the aviator. The instrument panel must be placed so that the 1st-percentile aviator can reach the panel. The Anthropometry of Naval Aviators (NAEC-ACEL-533), the Anthropometry of Army Aviators (TR EP-150), and the Anthropometry of Flying Personnel (WADC-TR 52-321) were used to determine the size of the 1st and 99th percentile men for this study, but none of these publications contains one necessary measurement, the aviator's maximum functional reach when restrained by a lap belt. This measure is basically the maximum arm reach upwards (as given in TR EP-150) rotated about the Seat Reference Point (SRP) and converted to functional reach. A study now in progress at the U. S. Army Human Engineering Laboratories furnished this measure, 46 inches for the 1st-percentile Army aviator. This was the value for maximum functional reach when restrained by a lap belt that was used in this paper. This measure was considered to extend from the SRP to the top of the instrument panel. Data presented in WADC TR 56-171 verified this value.

EVALUATION OF FACTORS

From Figure 1 the preferred eye-to-panel distance determined from 560 trials is 29.19 inches. These judgments were made by pilots and non-pilots. Figure 2 shows that visual angles in excess of 1.6 minutes of arc are required for 100 percent detectability. Table 1 shows that for a eye-to-panel distance of 40 inches the visual angle for stroke width, the critical measurement in letter recognition, is equal to the minimum value that is required for 100 percent detectability. Table 3 verifies the minimum illumination of .1 foot-candle as the requirement for 20/20 acuity. The physical size of the aviator also determines the placement of the instrument panel as well as his visual abilities.

A survey of pilots now flying helicopters was conducted to determine if vibration should be considered as a factor in this paper. It was the unanimous opinion of these pilots that vibration did not affect their ability to read any of the instruments.

TABLE 3

Relationship Between Illumination and Visual Acuity

Illumination Meter-Candles	Illumination Foot-Candles	Acuity	Snellen
.016	.0015	.075	20/267
.020	.0019	.150	20/134
.028	.0026	.210	20/96
.047	.0044	.300	20/67
.120	.01110	.370	20/54
.250	.0230	.500	20/40
.670	.0620	.750	20/27
1.500	.1390	1.000	20/20
16.700	1.5520	1.250	20/16
5400.000	501.7000	1.500	20/13

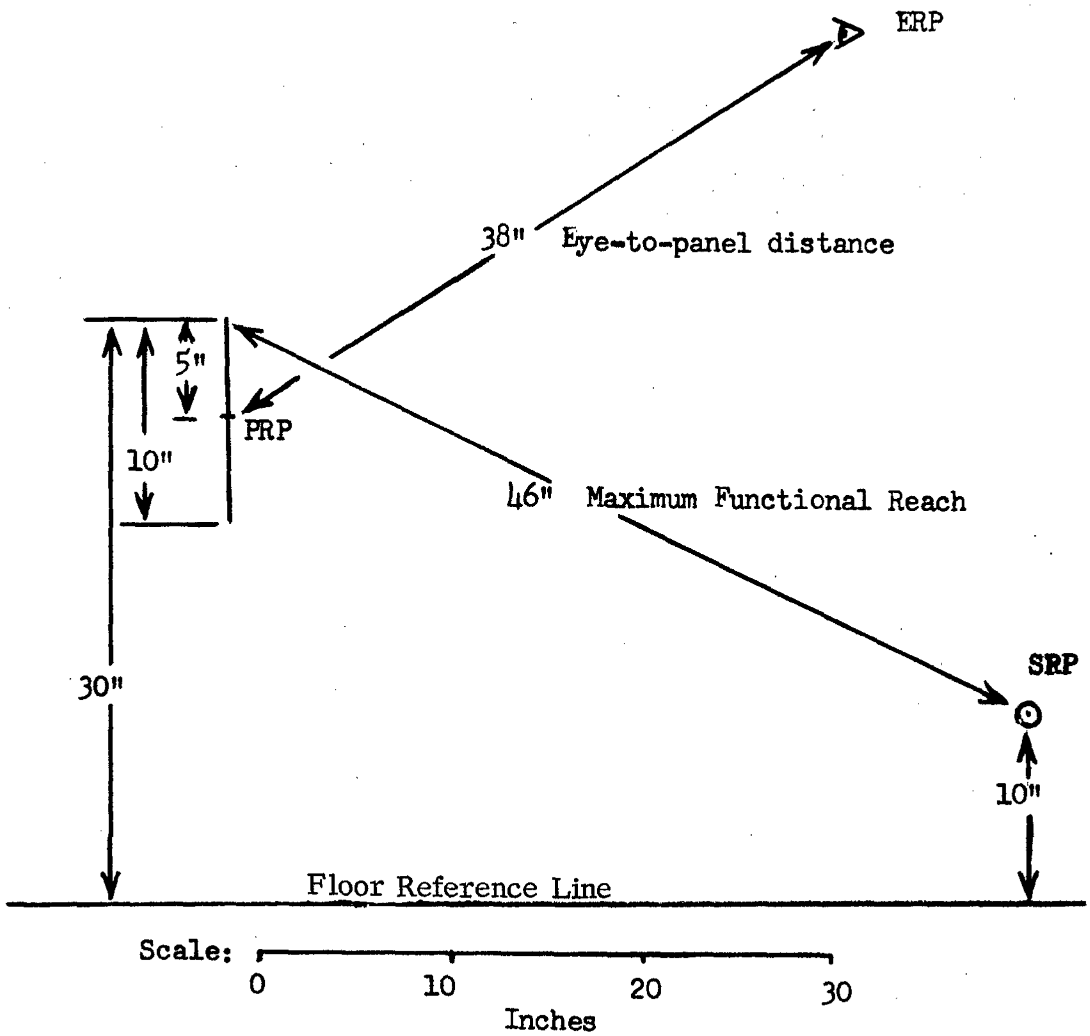

Fig. 4. INSTRUMENT PANEL, MAXIMUM PLACEMENT

Figure 4 illustrates the results of the evaluation of the factors discussed in this paper. The following are the factors:

1. Illumination levels of .1 foot-candles or greater.
2. Figure heights of .15 inches.
3. Stroke widths of .019 inches, 1/8 of letter height.
4. A 1st percentile maximum functional reach.
5. A 99th percentile Eye Reference Point (ERP).
6. A 10-inch seat height.
7. A 30-inch top of panel height.
8. Panel Reference Point (PRP) at 5 inches from panel top.

CONCLUSIONS

If the present indicator sizes, visibilities, and detection probabilities are to be maintained, aircraft instrument-panel viewing distances in excess of 38 inches are not permissible unless degradation of visual and operational capabilities below the 100 percent level can be justified.

REFERENCES

1. Baker, C. A. & Grether, W. F. Visual presentation of information. WADC-TR-54-160, Aero Medical Lab., Wright Air Development Center, Wright-Patterson AFB, Ohio, 1954.

2. Brown, F. R. The effect of stroke-width and form upon legibility of numerals. TED-NAMEL-609-4, Naval Air Material Center, Philadelphia, Pa., 1953.

3. Ely, J. H. et al. Layout of workplaces. WADC-TR-56-171, Aero Medical Lab., Wright Air Development Center, Wright-Patterson AFB, Ohio, 1956.

4. Graham, C. H. (Ed.) Vision and visual perception. New York: John Wiley & Sons, 1965.

5. Morgan, C. T., Cook, J. S., Chapanis, C., & Lund, M. Human engineering guide to equipment design. New York: McGraw-Hill, 1963.

6. Murrell, K. F. H., Laurie, W. D., & McCarthy, C. The relationship between dial size, reading distance and reading accuracy. Ergonomics, 1958, 1, 2, 182.

7. Obermayer, R. W., & Muckler, F. A. Preferences for instrument panel viewing distance. J. Eng. Psychol., 1962, 1, 4, 141.

8. Platonov, K. K. Voyennoye izdatel'stvo, Ministerstva Oborony Soyuza SSR, Moscow. Aviation Psychology, 1960.

9. Stevens, S. S. Handbook of experimental psychology. New York: John Wiley & Sons, 1951.

10. Tscherning, M. Physiologic optics. The Keystone, Philadelphia, Pa., 1904.

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13. ABSTRACT

The placement of the aircraft instrument panel has been governed by the 1947 recommendations of the Armed Forces-NRC Vision Committee. This distance, 28 inches from eye to panel, is not always compatible with present-day aircraft designs. A criterion for determining the placement of the instrument panel is developed and the maximum allowable eye-to-panel distance is given in this paper.

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